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Development of an Evaluation Methodology to Support the Generation IV Nuclear Energy Systems Technology Roadmap

Evaluation Methodology Group

Generation IV Roadmap Session
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Evaluation Methodology Group (EMG)

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Evaluation Methodology Group

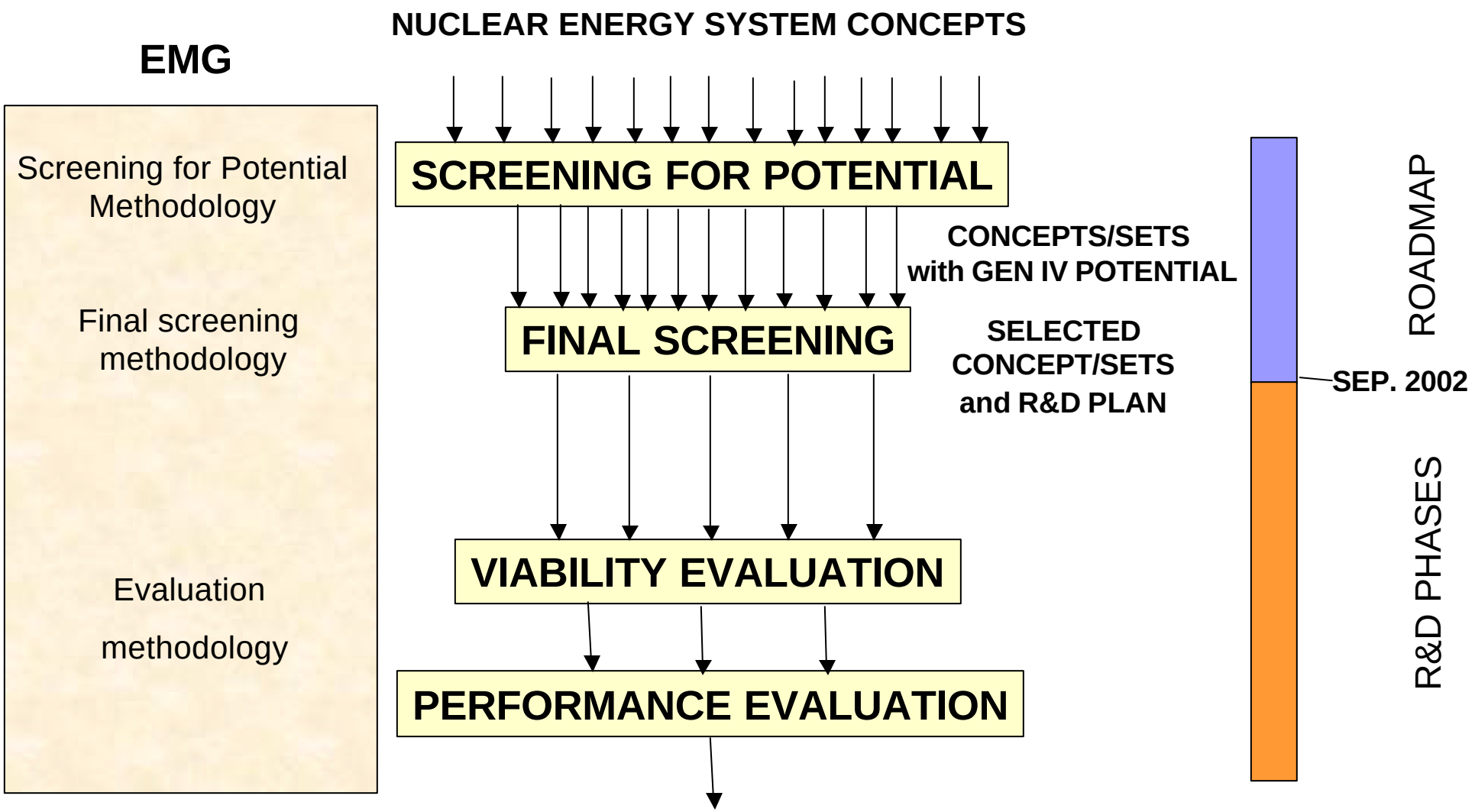
CHARTER

Develop a process for the systematic evaluation of the comparative performance of proposed Generation IV concepts against established Generation IV Goals

EMG DELIVERABLES AND SCHEDULE

- Screening for Potential Methodology **6/2001**
- Final Screening and R&D Prioritization Methodology **12/ 2001**
- Viability and Performance Evaluations Methodology and recommendation for methodology evaluation development **6/2002**

Evaluation Process



Screening for Potential

PURPOSE

Screening For Potential is to identify and include those nuclear energy system concepts that meet the purpose and principles of the Generation IV initiative and have the potential for significant progress toward the established goals.

MINDSET

The error of concern at this stage is to discard a “winning” concept - TWG burden: Justify dropping a concept.

The error of concern at later stages is to retain a “losing” concept - TWG burden: Justify retaining a concept.

Screening for Potential - Method

- Basic approach: assess the potential for a proposed concept to meet the Generation IV goals
  - Potential to meet the goals is assessed on the basis of a set of representative criteria and metrics (comparison to a reference - a characteristic Generation III system)
- TWGs assess a range, rather than a single point, for the concept potential
- Concepts are selected for their performance with respect to the criteria; that is, their potential to exceed the performance of the reference system
  - Only concepts whose range of potential is consistently below the reference are not considered further

Screening for Potential - Criteria

- Generation IV Goals are very broad in scope
  - A set of criteria that are *representative* of the intent of the goal are necessary
- EMG has developed a set of criteria for use in the Screening for Potential - a few (3-4) criteria for each Goal
  - The criteria are not exhaustive - do not necessarily cover all aspects included in one particular Goal
  - The criteria are indicative of the potential of the concept to meet the Goals
  - The criteria are useful to discriminate among concepts and with respect to the reference with the limited information available

Screening for Potential - Criteria

SUSTAINABILITY 1 - Generation IV nuclear energy systems including fuel cycles will provide sustainable energy generation that meets clean air objectives and promotes long-term availability of systems and effective fuel utilization for worldwide energy production

1 - Generation IV systems will reduce the depletion of nuclear fuel resources

2 - Generation IV systems will reduce their impact on the environment

3 - Generation IV systems will reduce the depletion of other specific resources

Screening for Potential - Criteria

SUSTAINABILITY 2 - Generation IV nuclear energy systems will minimize and manage their nuclear waste and notably reduce the long term stewardship burden in the future, thereby improving protection for the public health and the environment

1 - Generation IV systems will offer the opportunity for minimization and improved management of all wastes compared to the ALWR once-through reference system

2 - Generation IV systems will offer the opportunity for improvement of environmental and health impacts relative to current nuclear systems.

3 - Generation IV systems will minimize the stewardship burden on future generations. This includes facilities, wastes and repository monitoring and/or safeguards

Screening for Potential - Criteria

SUSTAINABILITY 3 - Generation IV nuclear energy systems including fuel cycles will increase the assurance that they are a very unattractive and least desirable route for diversion or theft of weapons-usable materials

1 - Generation IV systems will have intrinsic characteristics that minimize the life-cycle vulnerability of nuclear materials and facilities to theft, diversion, misuse and sabotage

2 - Generation IV systems will employ features that minimize the need for, and facilitate the application of extrinsic barriers

3 - Generation IV systems may use unique features that increase proliferation resistance

Screening for Potential - Criteria

SAFETY AND RELIABILITY 1 - Generation IV nuclear energy systems operations will excel in safety and reliability

1 - Generation IV nuclear energy systems will excel in reliability

2 - Generation IV nuclear energy systems will excel in safety and will not expose workers to significant risk via routine exposure to radiation or hazardous materials

3 - Generation IV nuclear energy systems will excel in safety and will not expose workers to significant accident hazard, involving radiation, hazardous materials, or severe physical conditions

Screening for Potential - Criteria

SAFETY AND RELIABILITY 2 - Generation IV nuclear energy systems will have a very low likelihood and degree of reactor core damage

1 - Generation IV facilities will have engineered safety features (for reactors: power control, heat removal, and radionuclide confinement) that will transparently bound the accessible range of operating and accident conditions and will allow the facility state to be predicted with very low uncertainty, inside this range of conditions

2 - Generation IV systems will be governed by dominant phenomena and phenomena interactions that can be predicted with very high and well-bounded certainty using models and experiments

3 - Screening for additional system characteristics that enhance or diminish the achievement of Goal SR2 can be applied here

Screening for Potential - Criteria

SAFETY AND RELIABILITY 3 - Generation IV nuclear energy systems will eliminate the need for offsite emergency response

1 - Generation IV systems will provide robust mitigation features to preclude harm to the public even if substantial thermal and oxidation damage occurs to fuel, or for non-reactor facilities, even if radioactive material is released from its immediate confinement, due to very-low probability event sequences

2 - In Generation IV systems, the phenomena that would govern system response after very-low probability event sequences leading to core damage (or to damage/criticality for non-reactor facilities) will be understood with high certainty

Screening for Potential - Criteria

Economics 1 - Generation IV nuclear energy systems will have a clear life-cycle cost advantage over other energy sources.

Economics 2 - Generation IV nuclear energy systems will have a level of financial risk comparable to other energy projects

1 - Generation IV systems will minimize the cost of constructing generating units

2 - Generation IV systems will minimize financial costs

3 - Generation IV systems will minimize production costs

4 - Generation IV systems will minimize development costs

5 - Generation IV systems will be highly profitable

Screening for Potential - Criteria

Examples of criteria and metrics

Sustainability Goal 1 - Resource utilization

Criterion 1 - Fuel Utilization

Assess the utilization of fuel resources compared to the ALWR once-through cycle

Systems that consume less fuel resources than the reference are rated positively. This includes higher burnups, conversion ratios, and recycling of fuel material

Much worse	Worse	Reference	Better	Much better
--	-	=	+	++

Final Screening

- EMG currently developing methodology for Final Screening
  - Capability for comparing and ranking concepts
  - Guidance for concept selection and R&D prioritization
- Definition of criteria and metrics
  - Definition of reference system (numerical when possible)
  - Better defined criteria and metrics (numerical scales with definition of the scale setpoints)
- A most probable value for the concept potential to be provided in addition to a range
- Scores in different criteria are rolled up to a single score per goal to obtain figures of merit for the concept potential

Summary

- A simple methodology has been developed for an initial screening of concepts for their potential to meet the Goals
  - Methodology is commensurate with information available
  - Methodology is being applied by TWGs; a few concepts are being identified for elimination
- Methodology allows for a qualitative assessment of concepts for their potential to meet Generation IV Goals
  - Assessment is based on a comparison to a Generation III reference
- A refined methodology for Final Screening is in development
  - Allow for comparison and finer discrimination among concepts
  - Allow for relative ranking of concepts to support selection